METHOD AND APPARATUS FOR CROSS-TALK MITIGATION THROUGH JOINT MULTIUSER ADAPTIVE PRE-CODING

BACKGROUND OF THE INVENTION

Technical Field of the Invention

This invention generally relates to the field of communication systems and, more particularly, to a method and apparatus for minimizing the effect of far-end cross-talk in a digital communication system.

Description of the Related Art

The speed at which digital communication systems provide users with information has grown over the years. The specific communication system used has evolved from a low data rate analog modem to the modern day high speed Digital Subscriber Line (xDSL) service. However, the physical transmission medium used to convey information to users has not changed. Typically, the transmission medium is "twisted pair" which is unshielded copper wires in close proximity to one another. Each twisted pair serves a respective user and is bundled with other twisted pairs, typically, in groups of 25 pairs.

Unfortunately, the proximity of each twisted pair to one another creates an impairment to transmitting information at a high speed. More specifically, when information is communicated on a twisted pair, the communication of that information interferes with communication on other twisted pairs. For instance, where you have a transmitting end of a circuit and multiple receiving ends, some or all of the receiving ends of the circuit can receive errors due to cross-talk from one interfering twisted pair in the bundle.

Cross-talk is especially problematic in high speed data transmission. Asymmetric Digital Subscriber Lines (ADSL), for example, offers data rates up to 8 Mb/s in the downstream direction (from the network to the home) and about one-eighth of this date rate in the upstream direction (from the home to the network). An even higher speed version of xDSL service is being

developed known as Very-high-speed Digital Subscriber Lines (VDSL) that targets data rates up to about 50 Mb/s for the downstream channel. As xDSL systems provide greater speeds, the xDSL service becomes more susceptible to interferences such as cross-talk.

Most of the work in this area has focused on optimizing spectral shaping of the transmitted signal by taking into account the cable loss and cross-talk loss to maximize the signal-to-cross-talk ratio. Other cross-talk reduction methods focus on mitigating single user cross-talk. The single user cross-talk approach, however, treats cross-talk interference as colored stationary or cyclostationary noise. Other cross-talk reduction methods address the issue of multi-user detection, which treats multiple receivers as one entity and performs joint detection.

Unfortunately, conventional multi-user detection methods for xDSL applications are not practical because the users are physically separate from one another. Thus conventional methods can not adequately address the issue of multi-user cross-talk detection and correction where the users are physically separate from each other.

SUMMARY OF THE INVENTION

The invention comprises a method and apparatus for mitigating cross-talk by deliberately combining (pre-coding) transmitted signals from multiple sources so that the effect of the pre-coding offsets the effect of cross-talk and the remote receivers can independently process the received signals as if the cross-talk does not exist.

BRIEF DESCRIPTION OF THE DRAWINGS

The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 depicts a high level block diagram of a communication system including the present invention;

FIG. 2 depicts a block diagram of a Multiple Input Multiple Output (MIMO) system;

FIG. 3 depicts an illustrative example of interference between communication channels in the communication system of FIG. 1;

FIG. 4 depicts a high level block diagram of a multiple channel transmission system according to an embodiment of the invention;

FIG. 5 depicts a high level block diagram of an alternate embodiment of the transmission system of FIG. 4;

FIG. 6 comprises a graphical representation of a learning curve for a defined number of iterations according to the present invention;

FIG. 7 comprises a graphical representation of the learning curve of FIG. 6 for a longer period of iterations;

FIG. 8 depicts a constellation diagram of the communications system of FIG. 1 before pre-coding;

FIG. 9 depicts a constellation diagram of the communications system of FIG. 1 after pre-coding according to the present invention; and

FIG. 10 depicts a high level block diagram of an embodiment of a controller suitable for use within a transmitter.

To facilitate understanding, identical reference numerals have been used, wherever possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be described in the context of four users utilizing Very high rate Digital Subscriber Line (VDSL) service. However, it will be appreciated by those skilled in the art that other types of DSL services and a varying amount of users can be serviced and still fall within the scope of the invention. While the present invention is described as using Carrierless Amplitude and Phase (CAP) modulation technology, the invention can be modified to use Quadrature Amplitude Modulation (QAM) and other modulation techniques.